Dithered Impulse	Peak Power Limited	-18
Pulsed FH (Partial Overlap of Hop Channels)	Peak Power Limited	-24 9
Pulsed FH (Complete Overlap of Hop Channels)	Peak Power Limited	-24 8
Pulsed FH (No Overlap of Hop Channels)	Peak Power Limited	-24.9
Pulsed FH (No Overlap of Hop Channels)	Average Power Limited	-18 3
Pulsed FH (No Overlap of Hop Channels)	Average Power Limited	-15 3

As shown in Table 4, the comparative interference power level of the pulsed FH signals are comparable to the non-dithered and dithered impulse signals. The values shown in Table 4 must be further adjusted for propagation loss and EESS receive antenna gain to estimate the actual interference power from the one vehicular radar. However, these extra loss values should be the same across all the signals analyzed, and have no effect on a comparative analysis. Thus, for the pulsed FH signal characteristics considered, one pulsed FH radar should be no worse, from an interference perspective, than one impulse vehicular radar.

The analysis in Appendix E is applicable only to assessing the interference impact to an EESS sensor because the effective interference signal at a space-borne sensor is an aggregate from a large number of vehicular radars. In addition, this aggregate signal is of concern over an extensive frequency range because the sensors have wide bandwidths on the order of 400 MHz. Thus, the frequency hopping of an individual radar as a part of an aggregate has a different impact in this case than frequency hopping devices would have in other frequency bands where they might operate in close proximity to relatively narrowband ground-based receivers. For ground-based receivers, a single frequency hoping transmitter would be dominant in setting the effective interference power level and only a relatively narrow frequency range is of primary concern. Therefore, the results of this analysis cannot be extended to assess the potential interference impact of a pulsed FH signal on ground-based receivers.

Based on the results of the comparative interference analysis, NTIA believes that the operation of pulsed FH vehicular radar systems that comply with the technical standards specified in Section 15.515 of the Commission's Rules is possible. In addition to the technical standards in Section 15.515, the rules must ensure that each hopping channel is used once and only once during the hopping sequence. The same hopping sequence is to be repeated each time.

VII. TECHNICAL AND ECONOMIC FACTORS MAY RESULT IN THE TRANSITION OF VEHICULAR RADAR OPERATIONS TO THE 77-81 GHZ FREQUENCY RANGE.

In response to the Commission's 76-81 GHz band realignment NPRM,[45] the Short Range Automotive Radar Frequency Allocation Group (SARA)[46] filed comments stating that at the current time, the 77 GHz band is not suitable for vehicular radar systems [47] SARA indicated that the much greater sensor cost at 77 GHz would render vehicular radars unviable.[48] However, SARA believes that they can reduce the cost of 77 GHz sensors within the next 10 years as new manufacturing processes are developed.[49] Technological advances, along with a more mature product will enable a more cost effective vehicular radar solution in the 77-81 GHz frequency range during the next decade As pointed out by Delphi Corporation, design, production, and deployment of vehicular radar systems in the 76-77 GHz band has commenced and continues at a steadily increasing pace [50] Long range vehicular radar systems known as adaptive cruise control (ACC) systems are currently being developed in the 76-77 GHz band. The Long-Range Automotive Radar Frequency Allocation Group expects the number of ACC systems deployed in the United States to increase significantly over the next few years, as improvements in the

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[45] *Amendment of Part 2 of the Commission's Rules to Realign the 76-81 GHz Band and the Frequency Range Above 95 GHz Consistent with International Allocation Changes*, Notice of Proposed Rulemaking, ET Docket No 01-102, FCC 03-90 (released April 28, 2003)

[46] SARA is an association composed of the world's leading automobile manufacturers and automotive component manufacturers

[47] Short Range Automotive Radar Frequency Allocation Group Comments, ET Docket No 03-102 (August 4, 2003) at 6 ("SARA Comments")

[48] *Id*

[49] *Id*

[50] Delphi Corporation Comments, ET Docket No. 03-102 (August 4, 2003) at 4

manufacturing process brings down the cost of the sensors.[51]

SARA also indicates that in order to achieve the economies of scale necessary to make the widespread deployment of vehicular radars possible, automakers need to be able to purchase and install the same units regardless of a vehicle's ultimate destination market.[52] The economies of scale, made possible by the international harmonization of spectrum allocations and service rules, can lower the overall development costs of new and innovative technologies, resulting in potentially lower prices and more widespread deployment of this life saving technology

In 2002, the United States adopted rules for UWB vehicular radars operating in the 24 GHz frequency range In developing the emission levels for the vehicular radars, the primary concern in the United States was the potential for interference to EESS passive sensors from vehicular radar systems. In order to protect the EESS passive sensors, the Commission's Rules require the vehicular radar systems to attenuate, by 25 dB below the value of -41.3 dBm/MHz, any emissions within the 23.6-24 GHz band that appear 38 degrees above the horizontal plane. For equipment authorized, manufactured or imported on or after January 1, 2005, this level of attenuation shall be 25 dB for any emissions within the 23.6-24 GHz band that appear 30 degrees or greater above the horizontal plane. For equipment authorized, manufactured or imported on or after January 1, 2010, this level of attenuation shall be 30 dB for any emissions within the 23 6-24 GHz band that appear 30 degrees or greater above the horizontal plane. For equipment authorized, manufactured or imported on or after January 1, 2014, this level of attenuation shall be 35 dB for any emissions within the 23.6-24 GHz band that appear 30 degrees or greater above the horizontal plane. These levels of attenuation can be achieved through the antenna directivity, through a reduction in output power or any other means.[53]

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[51] Long-Range Automotive Radar Frequency Allocation Group Comments, ET Docket No. 03-102 (August 4, 2003) at 7

[52] SARA Comments at 4

[53] *See* 47 C F R §15 515(c)

The value of weather, climate, and environmental data, information, and forecasts is growing in importance to the U.S. economy. According to some estimates, up to 40 percent of the approximately $10 trillion U S. economy is affected by weather and climate events annually.[54] As a consequence of population growth, the costs of U.S. disasters related to weather and climate are rising rapidly. Approximately 90 percent of all Presidentially declared disasters in the United States are weather related [55] As society becomes more sensitive to weather, the importance and accuracy of weather prediction for the protection of lives and property, and economic growth continues to increase. In order for EESS passive sensors to perform lower sensitivity measurements, needed for global climatic change monitoring and more accurate weather forecasts, greater protection from interference will be necessary. The compatibility analysis performed by NTIA, that formed the basis of the emission limits for impulse UWB vehicular radars,[56] used an interference criteria specified in International Telecommunication Union - Radiocommunication Sector (ITU-R) Recommendation SA.1029.[57] The ITU-R reviews and updates the interference criteria in ITU-R Recommendation SA.1029 on a regular basis to reflect improvements in the sensitivity of the sensors, and to take advantage of other technological advances. After NTIA performed its analysis to develop the emission limits for UWB vehicular radars, the ITU-R modified Recommendation SA.1029, lowering the interference criteria of the EESS passive sensors operating in the 23.6-24 GHz frequency band by 6 dB (i.e , -160 dBW/200 MHz to -166 dBW/200 MHz). SARA indicates that the current level of attenuation in the Commission's Rules required by 2014 will be difficult to achieve while maintaining the required functionality of vehicular radars required for the enhancement of

[54] National Research Council, Committee on NASA-NOAA Transition for Research to Operations, Satellite Observations of the Earth's Environment Accelerating the Transition of Research to Operations, The National Academies Press, Washington DC (2003) at 22 (Internal citations omitted)

[55] *Id*

[56] Hatch Letter at Attachment 2

[57] International Telecommunication Union-Radiocommunications Sector, Recommendation SA 1029-2, *Interference Criteria for Satellite Passive Remote Sensing* (2002).

road safety.[58] However, given the current and future protection requirements for EESS passive sensors, any increase in the emission levels in the 23.6-24 GHz band will compromise future weather forecasting capabilities.

European regulators are also currently addressing the best way to accommodate vehicular radar systems. In addition to the potential interference to EESS passive sensors, vehicular radars may interfere with fixed service links authorized to operate in Europe operating in the 24 GHz band. These fixed links will provide back haul communications in support of advanced wireless services. The European Communications Committee of the European Conference of Postal and Telecommunications Administrations has drafted a decision that recognizes that the 24 GHz band provides an immediate and cost effective solution for vehicular radars.[59] This draft decision requires that production of 24 GHz vehicular radars cease by 2014, at which time new vehicular radars would be limited to the 77 GHz frequency range (i.e., 77-81 GHz).[60] Therefore, after 2014 there may no longer be a common frequency allocation for vehicular radars unless the United States establishes an allocation in the 77 GHz frequency range.

NTIA believes that these technical and economic factors may result in the transition of vehicular radar operations to the 77-81 GHz frequency range. These factors include technology and manufacturing advances in the 77 GHz frequency range and cost reduction from economies of scale achieved through common frequency allocations to meet the growing needs of both the automotive industry and the government passive systems. NTIA and the Commission should continue to monitor the deployment of vehicular radars in the 24 GHz band, the technology advancements in the 77-81 GHz band, and the development of vehicular radars outside the United States NTIA will also work with the Commission to ensure that an adequate frequency

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[58] SARA Comments at 5 *See* 47 C.F.R. §15 515(c). The required level of attenuation of the vehicular radar emission in the 23 6-24 GHz EESS sensing band is required to increase to 35 dB by 2014

[59] SARA Comments at 3

[60] *Id*

allocation in the 77-81 GHz band is available for the operation of vehicular radar systems.

VIII. ELIMINATION OF THE MINIMUM BANDWIDTH REQUIREMENT IN THE DEFINITION OF A UWB TRANSMITTER IS NOT SUPPORTED BY THE PUBLIC COMMENTS, AND WILL POTENTIALLY DISRUPT CURRENT PRODUCT AND STANDARDS DEVELOPMENT EFFORTS, FURTHER DELAYING UWB DEVICE AVAILABILITY.

The Commission is proposing to eliminate the definition of a UWB transmitter in 47 C.F.R. Section 15.503(d) [61] The Commission's proposal would eliminate the minimum bandwidth requirement that is currently in the definition, permitting the operation of any transmission system on an unlicensed basis, regardless of its bandwidth, as long as it complies with the standards for UWB operation set forth in SubPart F of 47 C.F.R. Part 15. NTIA believes that the effect of this change would be to permit intentional emissions in the restricted bands from unlicensed devices authorized by Part 15 regardless of the bandwidth used by the device [62]

NTIA previously raised concerns with the Commission's proposal to eliminate the definition of a UWB transmitter.[63] NTIA believes the views expressed by commenters regarding manufacturers that would intentionally inject noise into their systems to meet the minimum bandwidth requirement, thus permitting operation under the UWB regulations, are overstated and do not represent a technical basis for eliminating the minimum bandwidth requirement. Furthermore, the intentional addition of unnecessary noise to a signal would violate the Commission's long-standing rules that devices be constructed in accordance with good engineering design and manufacturing practice. This requires that emanations from the device shall be suppressed as much as practicable.[64] It is NTIA's opinion that a device where noise is

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[61] MO&O/FNPRM at ¶ 166

[62] Part 15 intentional radiators generally are not permitted to operate in certain sensitive or safety related frequency bands that are designated as restricted bands that are listed in 47 C F R §15 205.

[63] Letter from Fredrick R Wentland, Acting Associate Administrator, Office of Spectrum Management, National Telecommunications and Information Administration, to Edmond J Thomas, Chief, Office of Engineering and Technology, Federal Communications Commission (February 12, 2003) ("Wentland Letter")

[64] 47 C F R §15 15(a)

intentionally injected into the signal should never be certified by the Commission.

A review of the public record indicates that there is very little support for the Commission's proposal. Three automotive commenters indicate that they favor the change, but offer no technical rationale for their support.[65] Moreover, there is a concern that this proposal, may adversely impact standards development activities that are currently ongoing within the Institute of Electrical and Electronics Engineers (IEEE) 802.15 Task Group 3a (802.15.3a).[66] This concern is raised by XtremeSpectrum, Inc (XSI), a UWB device manufacturer, stating that the industry is now going through the difficult process of developing global standards for UWB devices. XSI believes that changing the eligibility rules now will only increase the uncertainty and confusion, further delaying commercial availability of UWB products.[67]

In the First R&O, the Commission established technical standards (peak and average EIRP limits) and operating restrictions for different types of UWB devices based on their potential to cause interference.[68] NTIA believes that these technical standards and operational restrictions are necessary to ensure that UWB devices can co-exist with Federal systems. The analyses performed by NTIA to develop these technical standards and operational restrictions were all based on a wideband (e.g., 500 MHz) impulsive interfering signals. The analyses performed by NTIA did not consider interference from narrowband signals (e.g., noise-like, pulsed) which would be permitted if the Commission eliminated the minimum bandwidth requirement for UWB transmitters. Unlike UWB where the basic type of interfering signal is known (e.g., impulsive), for the Commission's proposal the potential types of signals for the Part

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[65] Comments of Siemens VDO Automotive AG, ET Docket No 98-153 (July 21, 2003) at 31, Comments of Short Range Automotive Radar Frequency Allocation Group, ET Docket No 98-153 (July 21, 2003) at 2, Comments of Delphi Automotive Systems Corp, ET Docket No 98-153 (July 18, 2003) at 8.

[66] UWB is emerging as a solution for the IEEE 802 15.3a standard. The purpose of this standard is to provide a specification for low-complexity, low-cost, low-power consumption, and high data rate wireless connectivity among devices. The standards development effort in IEEE 802 15.3a is focused on the 3 1 - 10 6 GHz frequency range

[67] XtremeSpectrum Inc, Reply Comments, ET Docket No. 98-153 (August 20, 2003) at 5

[68] MO&O/FNPRM at ¶ 5

15 devices are unknown. The Commission needs to provide more details on the types of signals that they would permit under their proposal, in order to perform the necessary compatibility studies with the diverse federal systems operating in this region of the spectrum.

In addition to these considerations, NTIA is concerned that the elimination of the minimum bandwidth requirement from the definition of a UWB transmitter will impact operations in the restricted bands in 47 C.F R. §15.205 due to the potential interference that could result. Under the current Part 15 rules, only spurious or unintentional emissions at or below a specified field strength are permitted in the restricted frequency bands The elimination of the minimum bandwidth requirement from the definition of UWB transmitter would effectively allow intentional emissions in these bands by any Part 15 device irrespective of the transmission system or modulation techniques employed. The long-term effects of such a significant change have not been studied. The National Aeronautics and Space Administration is currently undertaking a broad study program to examine the effects of UWB devices on the operations of government systems in several restricted bands. Upon completion the results of this investigation will be made available to the Commission.

NTIA does not support the Commission's proposal to eliminate the minimum bandwidth requirement from the definition of a UWB transmitter. The Commission's proposal does not appear to have a benefit to the public, and will only serve to disrupt the ongoing UWB product and standards development activities, possibly further delaying commercial product availability. Furthermore, the long-term effects of this proposal on government systems are not fully understood NTIA believes that the Commission has established a stable regulatory framework to facilitate the development of a broad range of commercial UWB device technologies and that it is now time to allow industry to develop products.

IX. MODIFICATIONS TO THE COMMISSION'S AMENDED SECTION 15.521(c) ARE NECESSARY TO ENSURE PREDICTABILITY AND CERTAINTY FOR APPLICANTS SEEKING TO CERTIFY UWB DEVICES.

In the MO&O, the Commission stated that the original wording of Section 15.521(c) of its Rules, 47 C.F.R. §15.521(c), which addresses regulation of limits on emissions produced by digital circuitry used within UWB devices, was unclear.[69] In order to provide clarity, the Commission amended Section 15.521(c) of its Rules in the MO&O without seeking public comment on this change.[70]

The intent of Section15.521(c) of the Commission's Rules is to permit emissions from digital circuitry contained within the UWB device to be at a higher level than those specified in SubPart F, as long at it can be clearly demonstrated that those emissions are due solely to the digital circuitry and are not to be radiated from the transmitter antenna. NTIA agrees with the Commission that the language of Section 15.521(c) required clarification. However, NTIA believes that further text modifications are necessary in order to achieve the intent of this section of the Commission's Rules, and recommends the following further revisions to the amendment of Section 15.521(c):

Section 15.521 Technical requirements applicable to all UWB devices

> (c) Emissions from digital circuitry ~~used to enable~~ associated with the operation of the UWB transmitter shall comply with the limits in Sec. 15.209, rather than the limits specified in this subpart, provided it can be clearly demonstrated that those emissions ~~from the UWB device are due solely to emissions from digital circuitry contained within the transmitter and that the emissions~~ are not ~~intended to be~~ radiated from the transmitter's antenna. ~~Emissions from associated digital devices, as defined in Sec. 15.3(k), e.g., emissions from digital circuitry used to control additional functions or capabilities other than the UWB transmissions, are subject to the limits contained in Subpart B of Part 15 of this part.~~

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[69] *Id* at ¶ 150

[70] *Id* The Commission concluded that since this change to the regulation is interpretive and only clarifies a standard that already has been adopted, prior notice and public comment are unnecessary

NTIA believes that these additional revisions will ensure predictability and certainty for applicants seeking to certify UWB devices.

X. CONCLUSION

NTIA and the Commission recognize the unique challenges that have been encountered in the development of the rules for UWB device operation. NTIA urges the Commission to consider carefully the issues raised in these comments in an effort to continue the workable arrangement of allowing UWB technology to evolve while protecting critical federal systems.

For the foregoing reasons, NTIA submits these comments.

Respectfully submitted,

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APPENDIX A

ANALYSIS OF POTENTIAL IMPACT OF THE PROPOSAL TO DEFINE THE PEAK POWER IN A 1 MHZ BANDWIDTH ON FEDERAL SYSTEMS

This appendix provides an analysis of the potential impact to Federal systems based on the proposed and current definitions of peak power for wideband Part 15 devices. The analysis will address the following federal receivers: Air Traffic Control Radio Beacon System (ATCRBS) (Interrogator); ATCRBS (Transponder); Global Positioning System (GPS); maritime radionavigation radar; pulsed radar altimeter; Traffic advisory and Collision Avoidance System (TCAS); Mode-S; Air Route Surveillance Radar (ASR)-7; and ASR-8.

CALCULATION OF PART 15 DEVICE PEAK POWER LEVELS

The current and proposed definitions of peak power for wideband Part 15 devices will be considered in this analysis. The current definition of peak power specifies a 20 dB peak-to-average ratio where the peak power is the total peak power. The proposed definition of peak power specifies a 20 dB peak-to-average ratio where the peak power is measured in a 1 MHz resolution bandwidth.

The current and proposed definitions of peak power are expressed in terms of a field strength of 5000 µV/m at a reference distance of 3 meters. The peak equivalent isotropically radiated power (EIRP) is determined from Equation A-1.

$$\text{EIRP (dBm)} = 20 \text{ Log } E_0 + 20 \text{ Log } D_{Ref} - 104.8 \qquad \text{(A-1)}$$

where:

E_0 is the field strength (µV/m);
D_{Ref} is the reference distance (m).

Using Equation A-1, the peak EIRP in a 1 MHz bandwidth is:

$$\text{EIRP} = 20 \text{ Log } (5000) + 20 \text{ Log } (3) - 104.8$$

$$\text{EIRP} = 74 + 9.5 - 104.8 = -21.3 \text{ dBm/MHz}$$

The difference between the current and proposed definitions of peak power is the bandwidth used in the compliance measurement. For the current definition, the peak power is specified as the total peak power of the signal The compliance measurement would be performed in a resolution bandwidth and a pulse desensitization correction factor is used to relate the measured power in the resolution bandwidth to the peak power of the signal. For the proposed definition the peak power is measured in a 1 MHz resolution bandwidth with no adjustment for the bandwidth of the signal being measured.

CALCULATION OF INTERFERENCE CRITERION FOR PEAK POWER INTERFERING SIGNALS

To properly assess the potential of the peak power of a signal to interfere with a receiver, detailed measurements are required that take into consideration the impact that different combinations of pulse width and pulse repetition frequency (PRF) have on the receiver signal processing. NTIA has performed a limited set of these types of measurements on a 4 GHz earth station receiver, however, this type of detailed information is typically not available.[1] For this analysis, general interference criterion will be developed for three categories of receivers: radars, aeronautical radionavigation, and GPS.

Radar Receivers

The probability of detection of a radar is a function of the signal-to-noise ratio (S/N), which will be used as the basis to develop the interference criterion for peak power interfering signals. For a probability of detection of 90%, an signal-to-noise (S/N) of 15 dB is required.[2] The signal level is based on a peak power and the noise is based on average power. For noise signals the nominal peak-to-average ratio is 10 dB Expressing the S/N is terms of peak power results in a $(S/N)_p$ of 5 dB. In this analysis a criterion of setting the Part 15 peak power level such that it does not exceed the peak noise level will be used. This results in a interference criterion of $(S/I)_p = 5$ dB This interference criterion will be used to assess the potential impact of the peak power from Part 15 devices to ASR-7, ASR-8, pulsed radar altimeters, and maritime radionavigation radars.

Aeronautical Radionavigation Receivers

The performance of the aeronautical radionavigation receivers considered in this analysis is based on the receiver's ability to recognize and detect a desired pulse. The interference criterion for the aeronautical radionavigation systems will be based on the impact that the peak power of a Part 15 device will have on the ability of the aeronautical receiver to recognize a desired pulse. There is a limited set of measured data that assesses the impact that peak power signals have on the performance of Distance Measuring Equipment aeronautical radionavigation receivers.[3] The performance of these aeronautical receivers is also based on the ability to recognize a desired pulse, thus this measured data will be used in the development of a general interference criterion for aeronautical radionavigation receivers.

Table A-1 summarizes the measurements for worse case coincidence of timing where an interfering pulse caused a loss in decodes. The power level of the interfering signal where the decode efficiency begins to deviate from the maximum value and the interference power level where there is a 5% reduction in decode efficiency are shown in Table A-1. These measurements were carried out with a desired signal at the measured sensitivity level. The $(S/I)_p$ values for the 5% degradation point are 4 dB, -3 dB, 9 dB, and -3 dB. The measurements represent an extensive range of receiver implementations and designs. Based on the measured data shown in Table A-1, the mean value is 1.75 dB.

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[1] NTIA Report 02-393, *Measurements of Pulsed Co-Channel Interference in a 4-GHz Digital Earth Station Receiver*, National Telecommunications and Information Administration (May 2002).

[2] Merrill I Skolnik, *Introduction To Radar Systems* (Second Edition) at 28

[3] Electromagnetic Compatibility Analysis Center, ESD-TR-79-103, *The Effects of JTIDS Signals on TACAN/DME Interrogator Circuitry and the Operational Equivalent Pulse Density* (December 1979)

Table A-1.

Receiver ID	Specified Sensitivity (dBm)	Measured[4] Sensitivity (dBm)	Decode Efficiency Deviation from the Maximum Value (dBm)[5]	Decode Efficiency 5% Below the Maximum Value (dBm)[6]
GA-A	-78	-84	-90	-88
GA-B	-82	-83	-82	-80
CA	-90	-89	-100	-98
CB	-90	-90	-88	-87

Another reference containing measured data showing the impact of peak power interference levels on the detection of desired signals for an aeronautical radionavigation system was reviewed.[7] The aeronautical radionavigation receiver that was tested was a general aviation ATCRBS transponder receiver. The ATCRBS transponder receiver tested had an intermediate frequency (IF) bandwidth of 4 MHz The ATCRBS signal has a specified pulse width of 0.8 ± 0.1 µsec and the pulses from the interfering signal have a spectral width of 3.5 MHz. Measurements were performed with the pulsed interfering signal operating at 1008 MHz and the ATCRBS transponder receiver operating at 1030 MHz. Specific measurements (involving additional filtering of the interfering pulsed signal) were carried out to determine that the interference effect was caused by the pulsed interfering signal passing through the skirts of the ATCRBS receiver filter rather than the pulsed interfering transmitter noise in the receiver passband.

The measurements were performed with a desired signal at the minimum triggering level which varied, throughout the test period, from -74 dBm to -77 dBm.[8] Measurements of ATCRBS transponder receiver selectivity show a rejection of 60 dB to an interfering signal at 1008 MHz.[9] The performance degradation measurements showed a decrease in detection of desired signals when the pulsed interfering signal power exceeded a level of -23 dBm at the receiver input.[10] This peak power signal level would be attenuated by 60 dB due to the receiver selectivity, resulting in an effective peak interference power level of -83 dBm Comparing this to the range of ATCRBS transponder desired signal levels (-74 to -77 dBm), results in $(S/I)_p$ levels ranging from 6 to 9 dB, where I is the peak power of the interfering pulse.

[4] *Id* at 107

[5] *Id* at 71

[6] *Id*

[7] Electromagnetic Compatibility Analysis Center, ESD-TR-79-103, *The Effects of High JTIDS Signal Levels on an ATCRBS Transponder* (December 1979)

[8] *Id* at 16

[9] *Id* at 20

[10] *Id* at 27

Although these $(S/I)_p$ values are a little higher than the results presented previously, they do support the rationale that an interfering signal approaching the amplitude of the desired pulse (e g., S/I slightly positive) and coincident in time, will inhibit the ability of the ATC receiver to correctly detect the desired signal. The impact of peak interfering signals can be somewhat mitigated if the interfering signal duty cycle is low, resulting in a limited number of errors, and can be further mitigated by error correction techniques providing a critical proportion of the desired pulsed are correctly detected.

Based on the results of these limited measurements, an $(S/I)_p$ of 2 dB is used in this analysis to assess the potential impact of peak power signals from Part 15 device to ATCRBS (Interrogator), ATCRBS (Transponder), TCAS, and Mode-S receivers.

GPS Receivers

The performance of GPS receivers has been shown not to be severely degraded by low duty cycle pulsed interfering signals. Most, if not all, GPS receivers are designed not to have an extensive dynamic range capability. This is a cost-effective measure as the received GPS signal level varies only over a small range of useful power levels. If the GPS signal is too low it is not useful. With a limited dynamic range, some element of the receiver will saturate at a relatively low level, acting like a limiter.[11] Some GPS receivers actually implement a limiter to protect it from any excessive interference The limiting action does not effect signals at normal levels, but it clips (e.g , blocks) higher powered signals. As long as the receiver has been designed to recover quickly from pulse interference, the clipping action caused by low duty cycle interference will usually not cause a GPS receiver to fail. The limiting action of a pulsed interfering signal blocks the GPS signal in the receiver. However, if this limiting action takes place only a small percentage of the time, the pulse signal is mitigated as long as the receiver front-end is protected from damage.[12] For the case of in-band pulsed interference, the RTCA derived criterion is a peak power level of +20 dBm for pulsewidths less than 1 millisecond and pulsed duty cycles less than 10%.[13]

RADAR ANALYSIS

ASR-7 and ASR-8

The ASR-7 and 8 operate in the 2700-2900 MHz band. The ASR-7 and ASR-8 will be characterized with a 4 dB noise figure, a 5 MHz IF receiver bandwidth, and a system loss of 2 dB. The receiver system noise is computed using the following equation:

$$N = -114 + 10 \text{ Log } (BW) + NF \qquad \text{(A-2)}$$

where:

N is the receiver system noise (dBm);
BW is the IF bandwidth of the receiver (MHz);

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[11] A limiter is a device in which some characteristic of the output is automatically prevented from exceeding a predetermined value

[12] Elliott D Kaplan (Editor), *Understanding GPS Principles and Applications*, Artech House, Inc (1996) at 214

[13] Document Number RTCA/DO-229B, *Minimum Operational Performance Standard for GPS/Wide Area Augmentation System Airborne Equipment* (January 1996)

NF is the noise figure of the receiver (dB).

Using Equation A-2, the receiver system noise is -102.6 dBm.

As discussed earlier, to achieve a probability of detection of 90%, the S/N is 15 dB and the system loss is 2 dB, the minimum peak signal level is computed by:

$$S_p = N + S/N + L_s \tag{A-3}$$

$$S_p = -102.6 + 15 + 2 = -85.6 \text{ dBm}$$

For the interference susceptibility criterion of $(S/I)_p$ of 5 dB, the peak interference threshold is:

$$I_p = S_p - (S/I)_p \tag{A-4}$$

$$I_p = -85.6 - 5 = -90.6 \text{ dBm}$$

Based on the proposal to define the peak power in a 1 MHz bandwidth, the EIRP is -21.3 dBm/MHz. Representing this in the 5 MHz IF bandwidth of the ASR-7/8 receiver results in:

$$EIRP_{peak} = -21.3 + 20 \text{ Log } (5 \text{ MHz}/1 \text{ MHz}) = -7.3 \text{ dBm}/5 \text{ MHz}$$

Using the current definition the peak EIRP is:

$$EIRP_{peak} = -21.3 \text{ dBm}/5 \text{ MHz}.$$

The maximum allowable EIRP for compatible operation is computed using the following equation

$$EIRP_{max} = I_{max} - G_R(\theta) + L_p + L_s \tag{A-5}$$

where:

I_{max} is the maximum allowable interference based on the interference susceptibility criterion (dBm);
$G_R(\theta)$ is the receive elevation pattern antenna gain in the direction of the Part 15 device (dBi);
L_p is the propagation loss computed using the Irregular Terrain Model (dB);[14]
L_s is the system loss (dB).

In Equation A-5 using the peak EIRP (based on the proposed and current definitions) as the maximum allowable EIRP and the elevation antenna pattern for the ASR-9,[15] the required distance separations for compatible operation with the ASR-7 and ASR-8 radars for the proposed and current definitions of peak power for a Part 15 device are: 1.6 km (proposed definition) and 200 m (current definition).[16] As shown in this analysis defining the peak power in terms of a 1

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[14] NTIA Report 82-100, *A Guide to the Use of the ITS Irregular Terrain Model in the Area Prediction Mode*, National Telecommunications and Information Administration (April 1982).

[15] NTIA Special Publication 01-43 at A-10

[16] The lowest separation distance considered in the analysis was 200 m

MHz bandwidth as proposed will increase the distance separation required for compatible operation by a factor of 8.

The analysis does not include the signal processing in the radar receivers. The effect of pulsed interference is difficult to quantify and is strongly dependent on receiver/processor design and mode of operation. In particular, the differential processing gains for valid-target return, which is synchronously pulsed, and interference pulses, which are usually asynchronous, often have important effects on the impact of given levels of pulsed interference. In general, numerous features of radiodetermination radars can be expected to help suppress low-duty cycle pulsed interference, especially from a few isolated sources.[17]

Pulsed Radar Altimeter

The pulsed radar altimeters operate in the 4200-4400 MHz frequency band and have a IF bandwidth of 30 MHz. In this analysis the desired signal will be calculated for both the minimum and maximum altimeter altitudes. The desired signal to peak interference power will then be calculated and compared to the interference criterion of $(S/I)_p$ of 5 dB.

In the UWB compatibility analysis the desired signal level at the minimum altitude of 30 meters was computed to be -30.4 dBm. For the maximum altitude of 1524 meters, the calculated desired signal level was computed to be -64.3 dBm.[18]

Based on the proposal to define the peak power in a 1 MHz bandwidth, the EIRP is -21.3 dBm/MHz. Representing this in the 30 MHz IF bandwidth of the pulsed radar altimeter receiver results in:

$$EIRP_{peak} = -21.3 + 20 \text{ Log } (30 \text{ MHz}/1 \text{ MHz}) = 8\ 2 \text{ dBm}/30 \text{ MHz}$$

The peak interference power level is calculated using the following equation:

$$I_{peak} = EIRP_{peak} + G_R - L_s - L_p \qquad \text{(A-6)}$$

where:

G_R is the pulsed radar altimeter receive antenna gain (dBi),
L_s is the system loss (dB);
L_p is the propagation loss (dB).

The propagation loss is calculated using the following equation:

$$L_p = 20 \text{ Log } F + 20 \text{ Log } D - 27.55 \qquad \text{(A-7)}$$

where:

F is the frequency (MHz),
D is the separation distance (m).

For a center frequency of 4300 MHz and using the minimum and maximum altitudes as

[17] Recommendation ITU-R M.1464, *Characteristics of an Protection Criteria for Radionavigation and Meteorological Radars Operating in the Frequency Band 2700-2900 MHz* (2000).

[18] NTIA Special Publication 01-43 at 4-18

the separation distances, the values of propagation loss are:

$$L_p = 20 \text{ Log } 4300 + 20 \text{ Log } 30 - 27\ 55 = 74.7 \text{ dB} \qquad \text{(Minimum)}$$

$$L_p = 20 \text{ Log } 4300 + 20 \text{ Log } 1524 - 27.55 = 108.9 \text{ dB} \qquad \text{(Maximum)}$$

For a receive antenna gain of 10 5 dBi and a 2 dB system loss, the peak interference power levels using Equation A-6 are:

$$I_{peak} = 8.2 - 74.7 + 10.5 - 2 = -58 \text{ dBm} \qquad \text{(Minimum)}$$

$$I_{peak} = 8.2 - 108\ 9 + 10.5 - 2 = -92.2 \text{ dBm} \qquad \text{(Maximum)}$$

The desired signal to peak interference power ratio is calculated using the following equation.

$$S/I_{peak} = S - I_{peak} \qquad \text{(A-8)}$$

For the minimum and maximum altitudes the values of S/I_{peak} are:

$$S/I_{peak} = -30.4 - (-58) = 27.6 \text{ dB} \qquad \text{(Minimum)}$$

$$S/I_{peak} = -64.3 - (-92.2) = 27.9 \text{ dB} \qquad \text{(Maximum)}$$

The computed S/I_{peak} values for the minimum and maximum altitudes are approximately 23 dB higher than the $(S/I)_p$ criterion of 5 dB. Therefore, the proposal to define the peak power in a 1 MHz bandwidth should not impact the performance of pulsed radar altimeter receivers.

Maritime Radionavigation Radar

The maritime radars operate in the 2900-3100 MHz band. The maritime radar will be characterized with a 4 dB noise figure, a 4 MHz IF receiver bandwidth,[19] and a system loss of 2 dB. The receiver system noise computed using Equation A-2 is -103.9 dBm.

As discussed earlier, to achieve a probability of detection of 90%, the S/N is 15 dB and the system loss is 2 dB, the minimum peak signal level computed using Equation A-3 is -86.9 dBm

For the interference susceptibility criterion of $(S/I)_p$ of 5 dB, the peak interference threshold computed using Equation A-4 is -91.9 dBm.

Based on the proposal to define the peak power in a 1 MHz bandwidth, the EIRP is -21.3 dBm/MHz. Representing this in the 4 MHz IF bandwidth of the marine radar receiver results in

$$EIRP_{peak} = -21.3 + 20 \text{ Log } (4 \text{ MHz}/1 \text{ MHz}) = -9.2 \text{ dBm}/4 \text{ MHz}$$

Using the current definition the peak EIRP is:

[19] The IF bandwidth of the marine radar can vary over a range of 4 to 20 MHz depending on the mode of operation

$$EIRP_{peak} = -21.3 \text{ dBm/4 MHz.}$$

Using Equation A-5, the peak EIRP as the maximum allowable EIRP and the elevation antenna pattern for the marine radar,[20] the required distance separations for compatible operation with the marine radars for the proposed and current definitions of peak power for a Part 15 device are: 1.9 km (proposed definition) and 460 m (current definition). As shown in this analysis defining the peak power in terms of a 1 MHz bandwidth as proposed will increase the distance separation required for compatible operation by a factor of 4.

The analysis does not include the signal processing in the radar receivers. As discussed for the ASR-7/8, the effect of pulsed interference is difficult to quantify and is strongly dependent on receiver/processor design and mode of operation. In particular, the differential processing gains for valid-target return, which is synchronously pulsed, and interference pulses, which are usually asynchronous, often have important effects on the impact of given levels of pulsed interference. In general, numerous features of radiodetermination radars can be expected to help surpress low-duty cycle pulsed interference, especially from a few isolated sources. The newer generation radar systems use digital signal processing after detection for range, azimuth and Doppler processing. Generally, included in the signal processing are techniques used to enhance the detection of desired targets and to produce target symbols on the display. The signal processing techniques used for the enhancement and identification of desired targets also provides some suppression of low-duty cycle interference, less than 5%, that is asynchronous with the desired signal.[21]

AERONAUTICAL RADIONAVIGATION RECEIVER ANALYSIS

The aeronautical radionavigation systems considered in this analysis operate at either 1030 MHz or 1090 MHz. The ATCRBS Interrogator is a ground-based receiver that will be analyzed differently than the ATCRBS Transponder, Mode S, and TCAS receivers which are airborne.

ATCRBS Interrogator

The minimum signal level for the ATCRBS Interrogator receiver to satisfy its reply detection probability is -79 dBm.

For the interference susceptibility criterion of $(S/I)_p$ of 2 dB, the peak interference threshold computed using Equation A-4 is -81 dBm.

Based on the proposal to define the peak power in a 1 MHz bandwidth, the EIRP is -21.3 dBm/MHz Representing this in the 9 MHz IF bandwidth of the ATCRBS Interrogator receiver[22] results in

$$EIRP_{peak} = -21.3 + 20 \text{ Log } (9 \text{ MHz}/1 \text{ MHz}) = -2.2 \text{ dBm/9 MHz}$$

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[20] NTIA Special Publication 01-43 at A-28

[21] Draft Revision of Recommendation ITU-R M 1464, *Characteristics of Radiolocation Radars, and Characteristics and Protection Criteria for Aeronautical Radionavigation and Meteorological Radars in the Radiodetermination Service Operating in the Frequency Band 2700-2900 MHz* (March 25, 2003) at 11

[22] The Mode S receiver has an 8 MHz IF bandwidth which will result in a a peak EIRP that is 1 dB lower than the value used in the analysis results

Using the current definition the peak EIRP is:

$$EIRP_{peak} = -21.3 \text{ dBm/9 MHz.}$$

In Equation A-5, using EIRP as the maximum allowable EIRP and the elevation antenna pattern for the ATCRBS Interrogator,[23] the required distance separations for compatible operation with the ATCRBS Interrogator receiver for the proposed and current definitions of peak power for a Part 15 device are: 570 m (proposed definition) and 200 m (current definition).[24] As shown in this analysis defining the peak power in terms of a 1 MHz bandwidth as proposed will increase the distance separation required for compatible operation by a factor of approximately 3. The proposal to define the peak power referenced to a 1 MHz resolution bandwidth does not dramatically increase the separation distance necessary for compatible operation and, therefore should not have an impact on ATCRBS Interrogator receiver performance

ATCRBS Transponder, Mode S, and TCAS

The minimum signal level for the ATCRBS Transponder, Mode S, and TCAS receivers to satisfy their reply detection probabilities are: -77 dBm, -79 dBm, and -74 dBm respectively.

For the interference susceptibility criterion of $(S/I)_p$ of 2 dB, the peak interference thresholds computed using Equation A-4 are -79 dBm for ATCRBS Transponder receivers, -81 dBm for Mode S receivers, and -76 dBm for TCAS receivers.

Based on the proposal to define the peak power in a 1 MHz bandwidth, the EIRP is -21.3 dBm/MHz. Representing this in the 9 MHz IF bandwidth of the TCAS receiver results in:

$$EIRP_{peak} = -21.3 + 20 \text{ Log } (9 \text{ MHz}/1 \text{ MHz}) = -2.2 \text{ dBm/9 MHz}$$

Using the current definition the peak EIRP is:

$$EIRP_{peak} = -21.3 \text{ dBm/9 MHz.}$$

Representing the peak EIRP in the 5.5 MHz IF bandwidth of the ATCRBS Transponder/Mode S receiver results in:

$$EIRP_{peak} = -21.3 + 20 \text{ Log } (5.5 \text{ MHz}/1 \text{ MHz}) = -6.5 \text{ dBm/5.5 MHz.}$$

Using the current definition the peak EIRP is:

$$EIRP_{peak} = -21.3 \text{ dBm/5.5 MHz.}$$

The analysis will consider an ATCRBS Transponder/Mode S and TCAS receiver used for en-route navigation. For en-route navigation, the aircraft will be at a minimum altitude of

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[23] NTIA Special Publication 01-43 at A-15

[24] The lowest separation distance considered in the analysis was 200 m

1000 feet (300 meters)[25] Using Equation A-7, the values of propagation loss for the ATCRBS Transponder/Mode S and TCAS receivers are:

$$L_p = 20 \text{ Log } 1030 + 20 \text{ Log } 300 - 27.55 = 82.2 \text{ dB} \qquad \text{(ATCRBS/Mode S)}$$

$$L_p = 20 \text{ Log } 1090 + 20 \text{ Log } 300 - 27.55 = 82.7 \text{ dB} \qquad \text{(TCAS)}$$

The receive antenna gains are: 4 dBi (ATCRBS), 5 dBi (Mode S), and 6 dBi (TCAS). The analysis will include a 2 dB system loss for all systems.

Using Equation A-5, the maximum allowable EIRP to satisfy the interference thresholds for ATCRBS, Mode S, and TCAS receivers are:

$$EIRP_{max} = -79 - 4 + 82.2 + 2 = 1.2 \text{ dBm} \qquad \text{(ATCRBS)}$$

$$EIRP_{max} = -81 - 5 + 82.2 + 2 = -1.8 \text{ dBm} \qquad \text{(Mode S)}$$

$$EIRP_{max} = -76 - 6 + 82.7 + 2 = 2.7 \text{ dBm} \qquad \text{(TCAS)}$$

The computed values of maximum allowable EIRP for compatible operation of the ATCRBS Transponder, Mode S, and TCAS receivers are above the EIRP values permitted by the proposal to define the peak power in a 1 MHz bandwidth. Therefore, the proposal to define the peak power in a 1 MHz bandwidth should not impact the performance of ATCRBS Transponder, Mode S, and TCAS receivers used for en-route navigation.

GPS RECEIVER ANALYSIS

The bandwidth for GPS receivers will vary depending upon the receiver architecture employed. For coarse/acquisition (C/A) code receiver architectures bandwidths of 1 to 2 MHz are typical; for narrowly-spaced correlator receiver architectures bandwidths are on the order of 12 MHz, and for semi-codeless receiver architectures the bandwidths approach 20 MHz The proposal to define the peak power in a 1 MHz bandwidth will have a potential impact on narrowly-spaced correlator and semi-codeless receiver architectures.

For the narrowly-spaced correlator receiver architectures, the proposed peak power definition expressed in a 12 MHz band is:

$$EIRP_{peak} = -21\ 3 + 20 \text{ Log } (12/1) = -21.3 + 21.6 = 0.3 \text{ dBm/12 MHz}$$

Using the current definition the peak EIRP is:

$$EIRP_{peak} = -21.3 \text{ dBm/12 MHz.}$$

Assuming a 0 dBi gain antenna, the peak power using both the current and proposed definitions are well below the +20 dBm threshold for in-band pulsed interference.

For the semi-codeless receiver architecture, the proposed peak power definition

[25] Document No RTCA/DO-235, *Assessment of Radio Frequency Interference Relevant to the GNSS* (January 27, 1997) at A-2

expressed in a 20 MHz band is:

$$EIRP_{peak} = -21.3 + 20 \text{ Log } (20/1) = -21.3 + 26 = 4.7 \text{ dBm/20 MHz}$$

Using the current definition the peak EIRP is:

$$EIRP_{peak} = -21.3 \text{ dBm/12 MHz.}$$

Assuming a 0 dBi gain antenna, the peak power using both the current and proposed definitions are well below the 20 dBm threshold for in-band pulsed interference.

The proposal to define the peak power referenced to a 1 MHz resolution bandwidth should not have an impact on GPS receiver performance.

APPENDIX B

ANALYSIS OF THE POTENTIAL IMPACT TO WIDEBAND PUBLIC SAFETY SYSTEMS OPERATING IN THE 4940-4990 MHZ BAND

This appendix provides an analysis of the potential interference impact to wideband public safety systems based on the proposed and current definitions for the peak power of wideband Part 15 devices.

The analysis will assume that a digital receiver has a bandwidth of 20 MHz, which is matched to the widest permitted transmit bandwidth permitted by the Commission's Rules. For the proposed peak field strength of 5000 μV/m at a reference distance of 3 meters the peak equivalent isotropically radiated power (EIRP) is determined from Equation B-1.

$$EIRP\ (dBm) = 20\ Log\ E_0 + 20\ Log\ D_{Ref} - 104.8 \qquad (B\text{-}1)$$

where:

E_0 is the field strength (μV/m),
D_{Ref} is the reference distance (m).

Using Equation B-1, the peak EIRP in a 1 MHz bandwidth is:

$$EIRP = 20\ Log\ (5000) + 20\ Log\ (3) - 104.8$$

$$EIRP = 74 + 9.5 - 104.8 = -21.3\ dBm/MHz$$

The peak EIRP of -21.3 dBm/MHz expressed in a 20 MHz bandwidth is:

$$-21.3 + 20\ Log\ (20/1) = 4\ 7\ dBm/20\ MHz$$

Using the current peak power definition, where the a 20 dB peak-to-average ratio is specified and the peak is the total peak power in a 20 MHz bandwidth, the peak EIRP would be 26 dB lower (20 Log (20)) than the value computed above or -21 3 dBm/20 MHz.

Thus, the difference in the peak power level between the current and proposed definitions is 26 dB

The system noise is calculated using the following equation:

$$N = -114 + 10\ Log\ (IFBW) + NF \qquad (B\text{-}2)$$

where:

IFBW is the receiver intermediate frequency bandwidth (MHz);
NF is the noise figure (dB)

Using Equation B-2, for the 20 MHz receiver bandwidth and a 5 dB noise figure the system noise is -96 dBm.

Measurements performed by NTIA on a digital receiver with a bandwidth of 20 MHz and error correction signal processing show the degradation of performance is directly related to the carrier-to-peak interference ratio (C/I).[1] The peak interference level is the level in the digital 20 MHz receiver bandwidth.

In order not to cause additional degradation of performance due to the proposed change in the definitions of peak power, the peak interference in the receiver would have to be reduced by 26 dB. That is the propagation loss would have to increase by 26 dB through increased distance separation to maintain the same performance.

The NTIA measurements were performed with a 15 dB signal-to-noise level which resulted in acceptable performance. With a noise level of -96 dBm calculated using Equation B-2, the resultant desired carrier signal level would be -81 dBm (-96 dBm + 15 dB). With an interfering duty cycle (in the receiver passband) of 0.01, the measurements show a range of susceptibility levels (depending on the interfering signal pulse repetition frequency (PRF)) from a C/I of -22 dB to +2 dB. Using a median susceptibility value C/I = -10 dB (corresponding to a PRF of 100 kHz) the peak interference threshold level in the receiver would be:

$$C/I = C - I \tag{B-3}$$

$$I = C - C/I \tag{B-4}$$

$$I = -81 - (-10) = -71 \text{ dBm}$$

The required distance separation for compatible operation assuming free space propagation loss is determined from the following equation:

$$20 \text{ Log } D_{Req} = -20 \log F - I + EIRP + G_R + 27.55 \tag{B-5}$$

where:

D_{Req} is the required separation distance (m);
F is the frequency (MHz);
I is the peak interference threshold level (dBm);
EIRP is the Part 15 device peak EIRP level (dBm);
G_R is the receive antenna gain (dBi).

Using peak EIRP calculated based on the current Part 15 definition, the mid-band frequency of 4965 MHz and a receive antenna gain of 0 dBi, the required separation distance is:

$$D_{Req} = 1\ 5 \text{ m}$$

The NTIA measurements also show a range of susceptibility C/I values of 0 to 8 dB for a interfering duty cycle of 0.1 Using the median C/I value of 4 dB (corresponding to a PRF of 100 kHz) Equation B-4 yields an interference threshold of:

$$I = -81 - 4 = -85 \text{ dBm}$$

Using Equation B-5, the required distance separation is:

[1] NTIA Report 02-393, *Measurements of Pulsed Co-Channel Interference in a 4-GHz Digital Earth Station Receiver*, National Telecommunications and Information Administration (May 2002) ("NTIA Report 02-393") at 13 (Figure 10)

$$D_{Req} = 7.4 \text{ m}$$

The distance separations of 1.5 and 7.4 m are based on the current definition of Part 15 peak limits. Using the same methodology the corresponding required separation distances for Part 15 devices operating at proposed peak power limits would have to be increased to take into account an additional 26 dB of propagation loss. Under free space propagation conditions, this results in an increase of approximately 20 times the distance or 30 and 150 m respectively.

The NTIA measurements examined the susceptibility of a digital receiver to pulsed interference as a function of pulse characteristics that included pulse width, pulse repetition rate, and peak amplitude. The measurements indicated that the digital receiver was relatively robust in the presence of low duty cycle interference. When the duty cycle was less than 0.005 (a half percent), interference thresholds exceeded the desired signal level. But interference thresholds converge rapidly to a continuous wave (CW) level when the duty cycle exceeds 1% The results were almost identical for all cases, regardless of absolute pulse repetition rate or pulse width, when the interference exceeds 5%. In that case, the interference threshold is nearly that of a CW signal. In effect, the digital receiver performance was severely affected if 5% or more of the symbols were deleted from the data stream.[2] This report only examined one error correction and bit interleaving implementation, thus the results could be different for other implementations.

As shown in this analysis, the proposed definition of peak power for Part 15 devices based on a 1 MHz bandwidth would increase the distance separation required for compatible operation by a factor of approximately 20 compared to the current definition of peak power which is based on the total peak power Depending upon the operational scenario considered this could be a potential problem

[2] *Id* at 19

APPENDIX C

MEASUREMENT TECHNIQUES FOR PULSED FREQUENCY HOPPING VEHICULAR RADARS

1. INTRODUCTION

The ultrawideband (UWB) First Report and Order (R&O) provides rules for the operation of UWB vehicular radar systems in the 22-29 GHz frequency range.[1] The Short-Range Automotive Radar Association (SARA), an association composed of the world's leading automobile manufacturers and automotive component manufacturers, is currently promoting the development and deployment of short-range vehicular radars operating in the 24 GHz frequency range.[2] These radars are being promoted as the core component of the next generation of collision mitigation and have the potential to reduce the incidence and severity of automobile accidents.[3] The various component manufacturing members of SARA are designing vehicular radars based on different modulation types. Siemens VDO (Siemens), a member of SARA, is designing a 24 GHz vehicular radar using a pulsed frequency hopping (pulsed FH) system.

The 23.6-24 GHz portion of the 22-29 GHz frequency band is a restricted band allocated to passive radio services such as the Radio Astronomy (RA) Service, the Earth Exploration Satellite Service (EESS), and the Space Research (SR) Service.[4] The rules adopted in the First R&O establish an emission mask and other restrictions on emission at higher elevation angles to facilitate compatibility with passive sensors used in the EESS.[5] All of the measurements and analysis used to develop these emission limits for vehicular radars were based on the analysis of impulsive UWB signals performed by NTIA.[6] NTIA, when assessing the potential interference impact to the EESS sensors or developing the compliance measurement procedures for impulsive UWB transmission systems, did not consider pulsed FH systems since this type of modulation was not considered by the Commission as being covered by the UWB rules.

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[1] *See* First Report and Order in ET Docket No 98-153, 17 FCC Rcd 7435 (released April 22, 2002) (hereinafter "UWB R&O") An Erratum to the First Report and Order was adopted on May 30, 2002 *See Erratum* in ET Docket No 98-153, 17 FCC Rcd 10505 (May 30, 2002) *See also,* 47 C.F.R §15 515

[2] SARA in its filed comments, has stated that there are advantages of vehicular radars operating in the 24 GHz frequency range as compared to those operating in the 5 8 GHz and 77 GHz frequency ranges

[3] *Ex Parte* Filing, Short Range Automotive Radar Frequency Allocation (SARA) Group in ET Docket No 98-153 (November 27, 2001)

[4] "Restricted bands" of operation are listed in 47 CFR § 15 205 With certain exceptions, the only emissions radiated from unlicensed devices, that are allowed in these bands are spurious emissions. Spurious emissions per 47 CFR 2 1, are emissions " which may be reduced without affecting the corresponding transmission of information "

[5] *See* C.F.R §15 515 (c), (d)

[6] Typical pulse widths used by UWB devices currently are on the order of 0 1 to 2 nanoseconds, or less, in width The emission spectrum appears as a fundamental lobe with adjacent side lobes that can decrease slowly in amplitude The rise time of the leading edge of the pulse and the pass band of the radiating antenna are major factors in determining the bandwidth of the UWB emission